Notional Joint Strike Fighter: Visualization and Mapping Data within the Virtual Strike Warfare Environments

Floyd Adagio
Pacific Sierra Research Corp., Arlington, VA

CDR Jon Lawler, RN
Joint Strike Fighter Program Office, Arlington, VA

ABSTRACT

Various levels of the military command infrastructure require visualization of data and fusion of tactical and strategic information. Specifically, visually oriented displays can provide intuitive, readily understandable information that is easily interpreted and acted upon. Visual systems provide a variety of data and information, including key elements such as maps, terrain elevation, imagery, iconic, symbology, and text. Use of these information forms must be specific to individual mission, yet consistent to all. Consistency among and between command levels is critical to support coordinated planning, execution, and after-action activities. Information forms and presentation to a user are constrained by system and cost considerations. This manuscript discusses the application of virtual, visualization environments within a hierarchical requirements structure based on warfighting functional requirements.

1.0 INTRODUCTION

The ability to convey information and to exploit it is an age-old issue. Plato referred to the purest of information as a *form* (Grube, 1974). He also discussed mental processes that are appropriate to military visualization within a continuum of mental processes, including understanding, reasoning, opinion, and imagination. The philosopher discussed his notion of forms as the highest level of knowledge. In the present as well as the past, the ability to impart the highest level of knowledge is critical to the human endeavor, whether in war or peace. Thus, the objective of providing the perfect information should strive to provide understanding by intuitive means at the form level of the knowledge continuum.

Today's visualization of military forms presents unique challenges and perplexing technological trade-offs. Achieving the right "look and feel" for combat data is difficult. A gap in communication and interpretation exists between users and developer. Decision makers of the slide rule generation are often determining system needs for operators who grew up with video games and personal computers.

2.0 DISCUSSION

Visualization requirements span a continuum from simple line depiction to fusion of multiple sources of data and rendering of high fidelity, geo-specific perspective scenes in real-time. The Joint Strike Fighter (JSF) Program has employed a Virtual Strike Warfare Environment (VSWE)

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **1999**	2. REPORT TYPE	3. DATES COVERED **00-00-1999 to 00-00-1999**

4. TITLE AND SUBTITLE **National Joint Strike Fighter: Visualization and Mapping Data Within the Virtual Strike Warfare Environments**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Joint Strike Fighter Program Office,Arlington,VA**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Proceedings of the Vector Moving Map Symposium, held in Alexandria, VA, 3-4 August 1999.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**7**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

to develop and refine requirements within an affordable and realistic modeling and simulation environment. This range of capabilities has been employed to support mission planning, rehearsal, execution, debrief, and intelligence efforts. Future VSWE efforts will support Test and Evaluation as well as Engineering and Manufacturing Demonstrations.

Several areas are impacted by visualization enhancements, as provided within US Defense Science and Technology Guidance for Joint DOD applications:

- Command, Control, Communications, and Computers (C^4)
  - *Provide common, accurate, mission-tailored picture to all warfighters*
  - *Develop ability to "learn" from users*
  - *Improve visualization*
- Intelligence, Surveillance, Reconnaissance (ISR)
  - *Improve situational awareness*
  - *Manage information and decision aids*
- Manpower / Personnel
  - *Determine optimum human/computer tasking*
  - *Improve decision-making*
  - *Reduce user workload*
  - *Reduce crew / manning requirements*

These capabilities will foster warfighter performance improvements and manpower reductions by tailoring displays to user requirements.

Consistent and repeatable visualization capabilities are critical throughout and among command levels. Examples of advanced applications for concurrent visualization at multiple levels include recent activities for Yugoslavian Operations: planning and rehearsal, exploitation within the JSF development program, investigation of US Secretary of Commerce Brown's crash, and conveying data to US National Command Authority. Simulated environments offer the opportunity to "see into the future" and allow operators to expand their understanding of future events while expanding situational awareness. These virtual environments also provide user-augmented reality with actual situations, which may have limited information resources. An example is evident in airborne applications to enable flexible targeting and re-tasking, as well as a context for off-board information fusion.

The Tactical Aircraft Moving Map Capability (TAMMAC) system is planned to support two-dimensional (2D) map requirements for naval aviation (table 1). Figure 1 provides an example of desired 2D rendering capabilities for the TAMMAC. Planned TAMMAC improvements include implementation of 3D functions. 3D perspective scene generation needs were assessed in terms of user suggested enhancements to F-18 and desired JSF capabilities.

Table 1. 2-D Requirements Based on the US Navy TAMMAC (Lohrenz, et al., 1997).

Change map scales and features in real-time	Magnify / Zoom from 1 to 2x in steps

Coverage area in standard scales (e.g., 1:500,000)	Programmable color palettes
Variable map scales between 2.5 – 250 nm	Standard symbol generation
Map orientation north-up or heading-up	Dynamic overlays
Center / de-center	Data frame rates
Sun / moon shading	Slewing

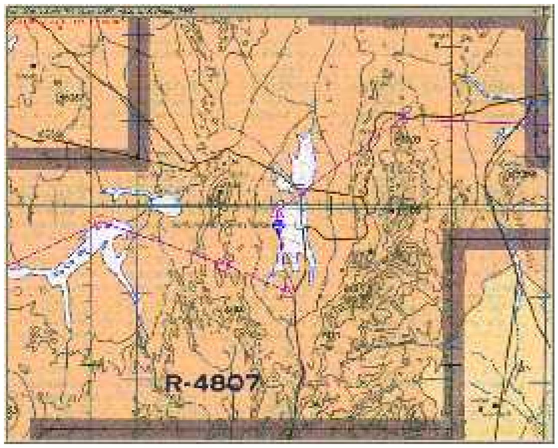

Figure 1. Example of 2D map display similar to 2D TAMMAC map.

Table 2 provides a list of 3D, scene perspective needs related to the JSF STT framework. Users have asked that future visualization also perform the following functions:

- Incorporate other sensor imagery.
- Simulate sensor and performance predictions.
- Extrude objects and buildings.
- Provide aircraft flight dynamics, weapon simulations, dynamic and accurate threats.
- Provide an interface to mission planning.
- Permit users to retrieve coordinates.

Figure 2 provides a notional view of a perspective scene using photo-based imagery, elevation data, and appropriate strike symbology (3D threats and target locations, approach restrictions, sensor updates and weapons effects). The 2D information portrayed in Figure 1 illustrates a display that requires interpretation by the user. The information in Figure 2 provides intuitive graphics in mission context for a strike platform. Additionally, the growth of communications and display techniques provides an opportunity to update this information within the mission timeline, providing expanded sensor data to the warrior. The intent is to provide Common Battlefield Awareness that provides command, control, and operational data to the user within the mission context.

Table 2. 3-D Requirements Based on the JSF Virtual Ground Map Functionality.

Multi-source / spectral data	Threat overlays
Multi-source / resolution elevation	Updated and real-time threat overlays
Geo-located/specific imagery and elevation	Multiple Fields of view
Display of vector products / data	Degrees of Freedom view angle control
Annotations and pointers	Remote and slewable eye point.

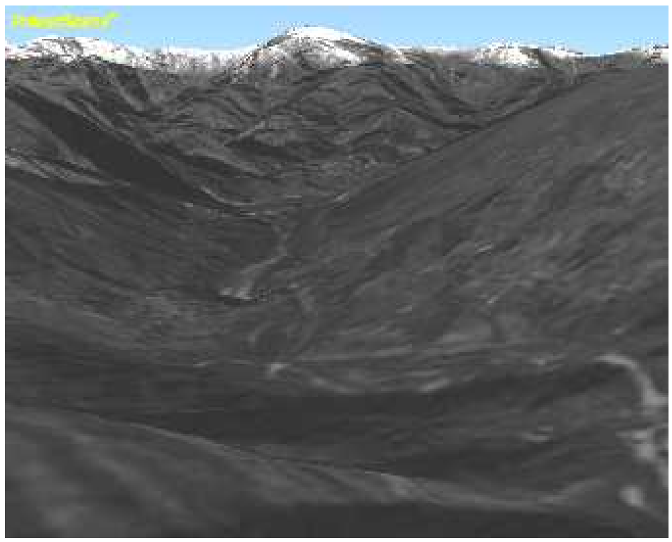

Figure 2. Notional view of perspective scene using photo-based imagery, elevation data, and appropriate strike symbology.

The utility of this data can be seen at various levels, as depicted in figure 3. During the JSF VSWE Event #4 held in Mesa, AZ (spring, 1999), two levels of visualization included 2D and 3D scene generation. Figure 4 provides an overview of the capabilities provided within the VSWE #4 cockpit. A video of this effort's goals and objectives was developed and the event's findings were included.

Preview, rehearsal, and data fusion (of intelligence and threat data) were performed at the mission level by providing enhanced command and control using an intuitive display. Additionally, "what if" scenarios can be played using advanced modeling, simulation, and analysis tools, which can be linked to higher level analysis using the JSF STT framework. Tactical information can be fused into scenes appropriate to a design of experiments and for real-time simulation use of data from multi-spectral databases, including elevation data, imagery, and advanced data-links provided in on-board databases fused with off-board resources. Data was also overlaid and updated via Intel sources.

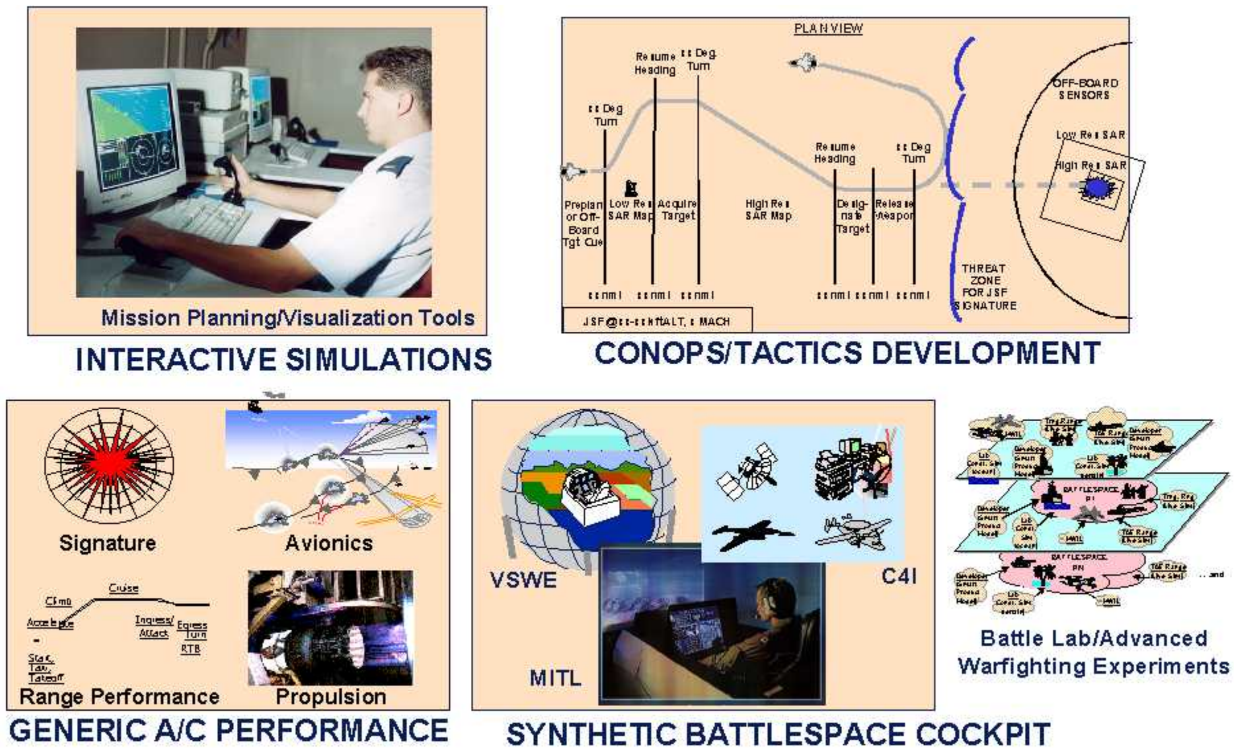

Figure 3. Virtual Strike Warfare Environment (VSWE) functions.

Operational level data was passed further to individual mission areas and exploited at lower levels by individual operators within a specific mission context. Integrated tactical displays linked to information resources at unit and command levels could provide current operational information beyond that available today. Such capabilities could enable flexible re-targeting and re-planning, in-flight updates with data and imagery, remote, future views within virtual reality concepts. Operational concepts might include video teleconferencing. At the mission level, virtual walk-through and fly-through capabilities would allow users to see through the next hill or discuss safe transit routes. Interfaces to mission planning resources could provide the view ahead and support position and maneuver control, visually augmented identification of friend or foe, as well as obstacle identification within tactical situation displays. Opening the operator's line of sight by projecting an outside view through the fuselage of an aircraft could provide a better understanding of the object in a larger context.

Two important principles that should guide future visualization developments are (1) an emphasis on using real-world photo-imagery, and (2) the use of portable, standardized software tools that do not require non-standard hardware. Additionally, military and commercial systems that support visualization should:

- Use and display real world data, from any perspective, and in any desired level of detail.
- Exploit imagery of varying scales, breadths, or resolutions from satellites, aerial photographs, and other sources.

- Combine the multi-source imagery with other data (such as maps and cultural features) into a seamless visual scene.
- Correlate the scene to real-world coordinates.

Figure 4. VSWE #4 cockpit capabilities.

3.0 SUMMARY

Future visualization techniques for military users include requirements to provide intuitive 2D and 3D data within a mission context. Present graphics techniques are expanding to provide consistency within military levels and individual operator needs and to provide greater opportunity within the C4I context. The users of these integrated techniques will foster the

development of enhanced operational concepts and future operations that will improve the military's abilities to reach strategic and operational goals.

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